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FLUORESCENT LIGHT CIRCUIT

Edward W. Banios, Hawthorne, Calif., assignor to Douglas Aircraft Company, Inc., Santa Monica, Calif.

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4 Claims. (Cl. 315-100)

This invention relates to fluorescent lighting, particularly lighting systems or circuitry for use under the severe conditions encountered in the cabins of high altitude transport aircraft.

Conventional fluorescent lighting systems, even those designed especially for aircraft use, exhibit certain characteristics which do not quite meet established requirements. Among other failings thereof may be mentioned the fact that their efficiency in low ambient temperatures is definitely low. For example, at 0° F. their actual efficiency is only 18% of rated efficiency, yet transport aircraft often fly in air-strata the temperature of which is -50° F.

More significant, perhaps, is the fact that, in an aircraft cabin, the conventional fluorescent lamp not only is a non-instantaneous starter, but will not start at all at any temperature below about -40° F.

The average service life of such lamps is of the order of 2500 hours, and about 74 of them are required in each cabin, which facts necessitate all too frequent replacement of these lamps.

Controlled "dimming" of the ordinary fluorescent lamp is not practical, for if it is attempted to any useful extent, the lamp will extinguish. In any event, when the lamp is about to "burn out," it does so in a prolonged series of intermittent flashes which annoy the passengers.

Again, as the wattage-capacity of the conventional fluorescent lamp "line" increases, a weight-penalty is incurred and with 74 high-wattage lamps used in one cabin, this penalty can no longer be ignored.

No standard preheat fluorescent light installed in conventional circuitry therefor can be made to start at a rate that can be properly designated "instantaneous," for a noticeable period of time elapses between closing of the circuit and incandescence of the lamp.

This invention provides a fluorescent lighting system and circuitry which, although its lamps consist, as usual, of a sealed transparent tube containing a "rare, atmospheric" gas under low pressure, with the inner surface of the wall of the tube coated with a phosphor to transform the ultra-violet radiations of its electric arc into visible light, nonetheless removes the aforesaid and other deficiencies of fluorescent lights when used in transport, or high altitude, aircraft.

The present unit comprises one or more such lamps and associated appurtenances configured in "close" circuit therewith. What ever specific form the electrical configuration may take, it essentially includes an electrical ballast and a reactor in series, the lamp being connected in parallel with one of the aforementioned units in this series circuit. The parametric values of the ballast and capacitor are made such that the reactances of the ballast and the reactor are rendered equal so that the series-combination will resonate at the usual frequency of the A.C. source, which is of the order of 400 c.p.s. When the lamp's switch is closed, this resonant circuit permits sufficient current to flow through the filaments of the

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lamp to suddenly raise their temperature, while a voltage large enough to arc the lamp through the pressurized gas therein is, by this same resonance phenomenon, generated across the capacitor. The result is substantially instantaneous starting in all circumstances except with extremely low voltage and in ambient temperatures below -40° F. The electrical ballast member, whether it be an inductance or a capacitor, thereafter acts to limit the current flowing to the lamp, whereas the reactor, either a capacitor or an inductance permits continuance of the filament heating.

A grounded "plate," which may be the altered reflector or the frame of the lamp or metallic foil adhered to the tube, is disposed in closer proximity to the lamp than the conventional reflector or frame and is otherwise so constructed and configured as to serve to lower the starting voltage required, as well as to stabilize low voltage operation and low temperature starting and operation. It is believed that the incorporation of this "plate" sets up a ground reference plane very close to the rear atmospheric gases in the tube in such a manner as to thereby create greater ionization in these gases. This augmented ionization enables lower-voltage starting and starting at lower ambient temperatures than otherwise possible.

The device may be employed for dimming service by the incorporation therewith, in the usual manner, of the standard variable auto-transformer for varying the circuit terminal voltage.

The circuit terminal voltage is non-critical and the filaments are continuously heated, prolonging the lamp life, which is of the order of 10,000 hours with 3,000 "starts." No "starter" is incorporated, obviating starter trouble and starter replacements. When the lamp fails, it does so sharply, instead of flickering in the usual manner.

Despite these advances, the weight-penalty imposed is small, compared to that incurred in increasing the wattage of conventional fluorescent lamps. For example, compared to the latter there are, in the present lamp and system, 1, 3, 4 and 6 ounce penalties, respectively, in increasing the wattage to 8, 15, 20 and 25 watts and no weight penalty at all at the 6 watt capacity. There is a 3 ounce weight saving in the present 30 watt circuit.

Other improved features and advances achieved by the invention will either be made manifest, or become apparent, hereinafter.

In order to render these and other concepts more concrete, several of the presently preferred embodiments thereof are shown in the accompanying drawings and are described hereinafter in conjunction therewith.

In these drawings, Fig. 1 is a diagrammatic view of that form of the present invention in which the fluorescent lighting circuit utilizes a lagging power factor;

Fig. 2 is a similar view in which the fluorescent lighting circuit employs a leading power factor;

Fig. 3 is a similar view in which a trimming capacitor is incorporated into the circuitry of Fig. 1;

Fig. 4 shows this trimming capacitor employed in the circuitry of Fig. 2;

Fig. 5 illustrates the circuitry of Fig. 1 as applied to a plurality of lamps in "bank" arrangement;

Fig. 6 depicts the circuitry of Fig. 2 applied to a plurality of lamps, the bank including means for stabilizing operation; and also including an "ionizing" condenser that affords smoother dimming with higher dimming ratios by virtue of the higher ionizing potential established by the additional condenser; and

Fig. 7 is a diagram of circuitry that includes an ionizing condenser for smoother "dimming" with higher dimming ratios.

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The unit shown in Fig. 1 includes an A.C. source 12, one "pole" 12A of which is grounded. The A.C. frequency is preferably 400 c.p.s. Connected in series with the "output" or positive, pole of the source, by means of a conductor path 12B, is an inductive ballast 13 having a coil 14 and a core, not shown. Further in series with the source 12 is a capacitor 17.

The lamp, including the usual tube 18, is shunted across the conductor path 12B between the ballast 13 and the capacitor 17, the positive filament, or anode, 19, being series-connected in 12B at this intermediate point and the negative filament, or "hot" cathode 20, being connected in 12B intermediate the capacitor 17 and the pole 12A of the source.

An ionization-augmenting plate 22, which may be the reflector or frame of the lamp, is disposed in close proximity to the one side of the lamp and is connected by a ground-wire 23 to the grounded leg of the conductor path 12B. It seems that the plate 22 serves as a "ground reference" plane for the rare atmospheric gases in the tube and otherwise augments the ionization therein. The augmented ionization minimizes the starting voltage necessary and also enables instantaneous "starts" at very low ambient temperatures. The effect of plate 22 becomes more marked as the original ionizing potential across the lamp decreases and also as the gas becomes less "active" at lowered ambient temperatures. The closer the element 22 is placed to the lamp, the better the "low-end" operation of the lamp. The invention contemplates that 22 may take the form of a strip of metallic foil coating one side of the lamp which is grounded, as well as taking one of the aforementioned forms.

Electric current flow through the lamp is preferably initiated by passing a current through the filaments and thus permitting application of a materially smaller voltage between them to vaporize the mercury and effect a gaseous electric discharge between electrodes. This is designated the "cathode pre-heat" type of lamp. It is conducive to longer electrode life, for during the conventional cold start, some of the electrode surface material is "boiled" off by the arc, whereas in the present instance no such damage occurs, since both electrodes soon reach a temperature of 950° C. At such elevated temperature, the electrode readily emits copious quantities of thermionic radiation, or electrons, which substantially instantly effect a gaseous electric discharge in the lamp.

It is preferred that the lamp tube be coated, on its inner surface, with some well-known phosphor or phosphorescent compound which produces a "warm-white" light.

The conventional 30 watt ballast is of the auto transformer type, but ballast 13 is, in contrast, a series choke ballast, preferably rated as 95-100/mh. and 600 ma., for the present resonant-start circuit. Preferably, for the present lamp when rated at 30 watts, the capacitor 17 has a rating of 1.75 microfarads.

This circuit can be constrained to afford dimming by means of having the voltage across it varied by the incorporation of a well-known variable auto-transformer in the conventional hook-up, if desired. By virtue of the resonance, the lamp dims "instantaneously" throughout its range. It can be instantly extinguished while very dim and relit instantly at this same level.

The proportions of the lagging and leading power factor circuits can readily be so chosen that the system power factor can be easily corrected, or rendered equal to unity.

Because of the ability to employ an unconventionally high power source frequency, it is feasible to operate the lamp at 8-10% higher currents than in conventional, giving about 8-10% more light output than usual.

The lagging power factor has been found to have almost linear dimming characteristics when used with the present lamps, especially those that have seen service, that is, have "aged."

In another one of the presently preferred embodiments

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of the invention, such as that illustrated in Fig. 2, a leading, instead of a lagging, power factor A.C. source, 12C, is employed. Also, the positions and functions in the circuit of the capacitor and the inductance aforementioned are, here, reversed, the capacitor device 17 now being disposed between the lamp's input terminal and the A.C. source and serving as a ballast device, while the inductance device 13 is constrained to serve as an inductive reactor. Otherwise, the configuration is the same. The ballasting capacitor 17 limits the current received by the lamp so that the resulting current leads the terminal voltage. Thus, for a 20 watt unit, for example, the circuit has a leading power factor of the order of .500. The other characteristics of this unit are the same as for the lagging power factor unit except that in Fig. 2 the inductive power factor is not so low. However, this second species of unit, having a low leading-power factor is capable of correcting the system's power factor if it lags too much.

An equal amount of each of the circuit capacity and arrangement of Figs. 1 and 2 is contemplated as feasible for use, so as to produce unity power factor; or the leading power factor species could be so combined with the "lagging" species as to correct an overly-lagging power factor of the system.

It is to be noted that the unit or circuitry of Fig. 2 possesses a non-linear dimming characteristic as contrasted to the substantially linear dimming property of that of Fig. 1; however, in Fig. 2 the age, or extent of use of the lamp plays a smaller role, in low-level lamp operation, than it does in the aforesaid circuit with a lagging power factor.

Another embodiment of the invention is shown in Fig. 3. Here, the system is substantially the same as that of Fig. 1 with the inclusion of a capacitor 24 for enabling the establishment of a highly tuned resonant circuit during lamp pre-arcing conditions while preventing passage of excessive current through the electrodes 19 and 20.

13, and the two capacitors coact to form the main capacitive components of the system. It is accordingly unnecessary to enlarge the capacitor 17, for such would afford excessive current flow through the electrodes. Instead, the needed "extra" capacitance for effecting an unusually highly tuned resonant circuit is supplied by capacitor 24, in Fig. 3, which capacitor cannot have any detrimental effect upon the electrodes, such as arcing and burning out. However, the combination 13 to 24, inclusive, is here so designed that their components remain far enough away from mutual resonance as to fail to "pull" a large current when the lamp is being removed or when a filament burns out.

Fig. 4 shows a system essentially like that of Fig. 3 so far as the additional capacitor is concerned, but the circuitry is otherwise like that of Fig. 2; that is, the inductance 13 and capacitor 17 are here in the Fig. 2 positions.

In Fig. 5, the specific circuitry of Fig. 3 is shown as employed to operate a plurality, or a bank, of the lamps 18 arranged in series, each of the lamps being provided with a grounded reflector 22, a single "trimming" capacitor 24 being employed for all three lamps. "Instantaneous" starting of all these lamps, simultaneously, is assured by this circuitry, for the generic reasons set forth hereinabove.

In Fig. 6, the principle of Fig. 4 is shown as employed to effectuate substantially instantaneous starting of a plurality of lamps, 18, arranged in series as a "bank." In addition, however, the negative filament or electrode of the one lamp is connected to the positive filament of the next lamp by a condenser, 40, in each of the legs of the connecting conductor path. Condensers 40 constitute means setting up an operation-stabilizing circuit for the lamps that becomes quite effective upon completion of the starting phase.

The circuitry of Fig. 7, by incorporating a capacitor 26 between reflector 22 and the negative lamp-electrode 20,

establishes an ionization augmenting potential difference between the electrodes 19, 20 and reflector 22, so as to afford smoother dimming action, while exhibiting still higher dimming ratios. That is, capacitor 26 raises the potential of electrode 20 with respect to plate 22 in effecting the aforesaid augmentation of ionization.

Whatever variant of the basal circuits of Figs. 1 and 2 may be employed, therefore, the invention requires that the particular circuit (1) be such as to establish a resonant condition therein prior to the actual arcing of the lamp, preferably by impressing the generated voltage across one of the resonating reactors in circuit across the lamp electrodes and (2) to supply a ballasting series impedance for the lamp during the lamp's post arcing period. The invention also provides means to heat the lamp filaments by passage of current therethrough in conjunction with arc-impingement thereon, in order to smooth out the operation of the circuit and the lamp during starting and dimming of the lamp.

Although certain shapes, compositions and parameters have been recited in describing various embodiments of the invention, it is to be definitely understood that such were employed only to render the description more concrete and that they in no wise limit the scope of the invention except as required by the sub-joined claims.

I claim:

1. A "starter-and-running" circuit for fluorescent-lighting, comprising: a source of electrical energy having a predetermined frequency; at least one conductor path in circuit therewith; a pair of lamp electrodes connected in series in said conductor path; and a plurality of reactor-means mutually interconnected in said conductor path and connected with the electrodes, with the frequency-response characteristics of said means so correlated with reference to each other and to the frequency of said source as to render their reactances equal and resonant with said source for instantaneous starting; at least one of said reactor-means having impedance-characteristics so arranged and correlated with said source and with the remainder of the circuitry as to ballast the operation of the light after starting there being a tuning condenser shunted across said plurality of reactor means and disposed electrically anterior to said electrodes.

2. A circuit for fluorescent lighting, comprising: a source of electrical energy having a predetermined frequency; a conductor path in circuit therewith; a pair of lamp electrodes in said path and connected in series with the source; a plurality of reactor-means mutually interconnected in said conductor path with the frequency-response characteristics of said means so correlated with reference to each other and to the frequency of said source as to render their reactances equal and resonant with said source; a first one of said reactor-means being an inductance electrically interposed in said conductor path in series with said electrodes and a second one of said reactor-means being a capacitor interposed in said

conductor path electrically anterior to said electrodes; there being a tuning capacitor shunted across said conductor path in parallel with the first and second ones of said reactor-means, and said tuning capacitor being disposed electrically anterior to said electrodes.

3. A "starter-and-running" circuit for fluorescent-lighting, comprising: a source of electrical energy having a predetermined frequency; a conductor path in circuit therewith; at least one pair of lamp electrodes connected in series in said conductor path; and a plurality of reactor-means mutually interconnected in said conductor path and connected with the electrodes with the frequency-response characteristics of said means so correlated with reference to each other and to the frequency of said source as to render their reactances equal and resonant with said source for instantaneous starting; there being a tuning condenser shunted across said plurality of reactor means and disposed electrically anterior to said electrodes; one of said reactor means being an inductance electrically interposed in said conductor path in series with said electrodes and another of said reactor-means being a capacitor electrically interposed in said conductor path electrically anterior to said electrodes.

4. A "starter-and-running" circuit for fluorescent-lighting, comprising: a source of electrical energy having a predetermined frequency; a conductor path in circuit therewith; at least one pair of lamp electrodes connected in series in said conductor path; and a plurality of reactor-means mutually interconnected in said conductor path and connected with the electrodes with the frequency-response characteristics of said means so correlated with reference to each other and to the frequency of said source as to render their reactances equal and resonant with said source for instantaneous starting; at least one of said reactor-means having impedance-characteristics so arranged and correlated with said source and with the remainder of the circuitry as to ballast the operation of the light after starting; there being a tuning condenser shunted across said plurality of reactor means and disposed electrically anterior to said electrodes; one of said reactor means being an inductance electrically interposed in said conductor path in series with said electrodes and another of said reactor means being a capacitor electrically interposed in said conductor path electrically anterior to said electrodes.

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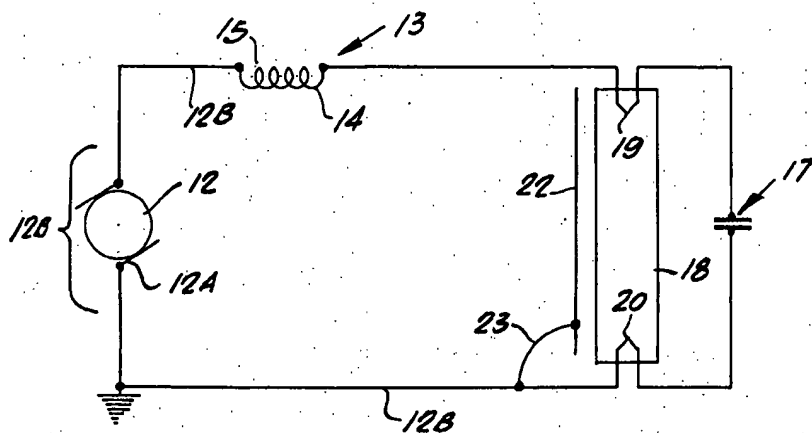
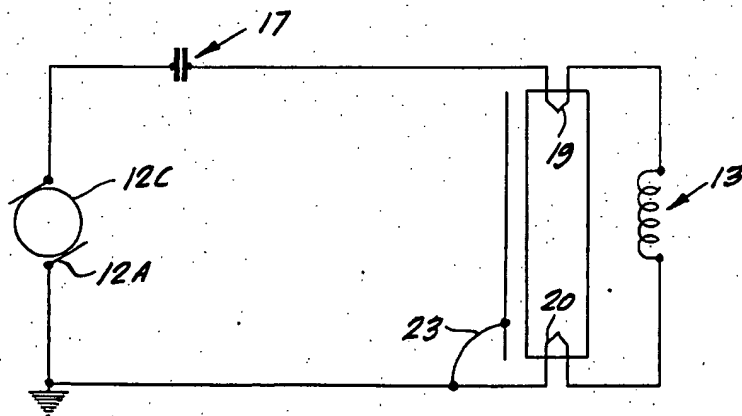
E. W. BANIOS

2,923,854

FLUORESCENT LIGHT CIRCUIT

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2 Sheets-Sheet 1

Fig. 1Fig. 2

INVENTOR.

EDWARD W. BANIOS

BY

Edwin Coates
ATTORNEY.

Feb. 2, 1960

E. W. BANIOS

2,923,854

FLUORESCENT LIGHT CIRCUIT

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2 Sheets-Sheet 2

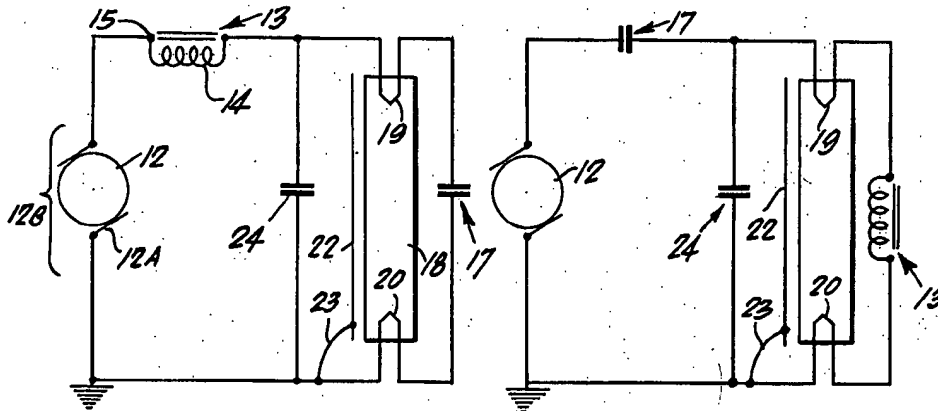


FIG. 3

FIG. 4

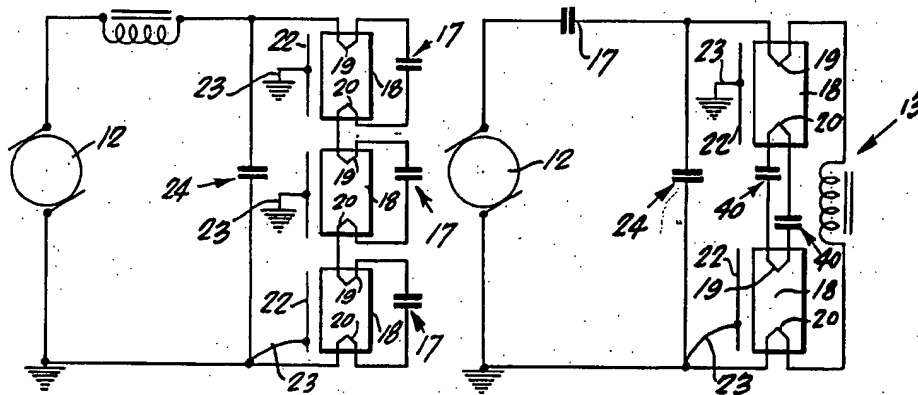


FIG. 5

FIG. 6

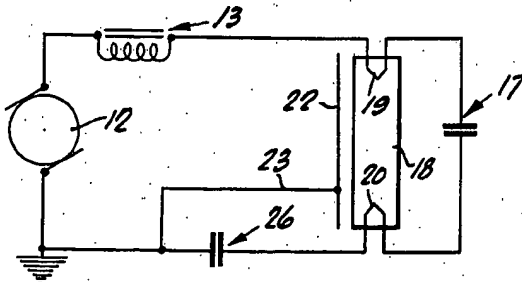


FIG. 7

INVENTOR.
EDWARD W. BANIOS

BY
Edwin Coates
ATTORNEY